



N 73-20126

CR-131291

SCIENTIFIC AND TECHNICAL SERVICES
IN THE DEVELOPMENT OF PLANETARY QUARANTINE
MEASURES FOR AUTOMATED SPACECRAFT

FINAL REPORT

Prepared under
Contract NASw-2372

**CASE FILE
COPY**

For

Headquarters

National Aeronautics and Space Administration
Planetary Quarantine Office
Washington, D. C. 20546

March 1973

by

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TR73-F



FOREWORD

This report summarizes the work performed during the first year of scientific and technical support to the Planetary Quarantine Officer under Contract NASw-2372. The reporting period extended from April 1, 1972 to March 31, 1973.

Technical review of the work was performed by Dr. L.B. Hall, NASA Planetary Quarantine Officer, assisted by Mrs. S. Gallagher, Project Monitor and Mr. M. Christensen on assignment from the Jet Propulsion Laboratory until February 1, 1973.

Exotech's work was directed by Mr. S. Schalkowsky. Messrs. R.G. Lyle and E.J. Bacon managed the special studies group and the project office team respectively.



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INTRODUCTION

The NASA Planetary Quarantine Program conducts a research and a flight project control program designed to insure that:

- United States planetary missions do not carry to and infect the environment of extraterrestrial bodies with terrestrial life, and
- spacecraft do not carry on board viable life that will confuse life detection experiments.

The Planetary Quarantine Officer, working through the Committee on Space Research (COSPAR), assists in establishing international and national standards. In this role, he utilizes advisory groups including the National Academy of Sciences Space Science Board, the NASA Physical Sciences Advisory Committee's Life Sciences Committee and the American Institute of Biological Sciences.

The measures used to achieve compliance with these standards include trajectory control, decontamination and sterilization. Management practices include the establishment of requirements for flight missions by the Planetary Quarantine Officer, compliance by the flight mission and inspection and certification by the Planetary Quarantine Officer. The Planetary Quarantine Officer also funds and directs a research program in university, industry and government laboratories designed to achieve the technical objectives of the program with minimum stress on the spacecraft at minimum cost.

Contract NASw-2372 was initiated on April 1, 1972 to provide NASA's Planetary Quarantine Officer with scientific and technical services directed



toward the development of planetary quarantine measures for automated spacecraft. These services included:

- Support the planetary quarantine research program with systems analysis techniques.
- Provide research integration where needed.
- Maintain planetary quarantine operational records.
- Evaluate operational plans.
- Support technology transfer between research efforts and flight projects.
- Supply technical support to the Planetary Quarantine Officer.

The effort was principally directed toward the broad development of NASA planetary quarantine management and technology applicable to flights to planets of biological interest with emphasis placed upon:

Viking '75
Pioneer F and G
Mariner Venus-Mercury '73

To provide a framework for interrelating results and for measuring the effectiveness of the products of this contract, we have related the many tasks undertaken to the primary goals of the Planetary Quarantine Program. This goal-oriented approach was employed during the performance of the work to provide a basis for task planning and resource allocation.

These primary goals and the tasks which principally relate to them are shown in Table 1.

TABLE 1
RELATIONSHIP OF CONTRACT TASKS TO PROGRAM GOALS

<u>Program Goals</u>	<u>Contract Task #</u>	<u>Contract Task Description</u>
Establishment of Realistic Planetary Quarantine Requirements and Standards	1	Evaluation of the Impact of Changes in Requirements
	3	Microbial Contamination Logs
	4	Maintenance of Allocation Bank
	5	Creation and Maintenance of List of Approved Parameters
	9	Preparation of Technical Presentations
Provide Data, Techniques and Guidelines for Flight Project Planetary Quarantine Planning	4	Maintenance of Allocation Bank
	6	Preparation of Technical Information Memo
	8	Supporting Analysis of PQ Sterilization Parameters
	10	Technical Support at Meetings
	11	Support of Technology Transfer
	13	Integrated Resumes of NASA Research
Assure Flight Project Compliance with Requirements	2	Maintain and Operate the Planetary Quarantine Document System
	7	Evaluation of Flight Project Quarantine Plans
	12	Preparation of PQ Schedule



TASK SPECIFICS

Task 1. Evaluation of the Impact of Changes in Planetary Quarantine Requirements.

Planetary quarantine requirements and parameters result from standards developed by COSPAR, recommendations made by the Space Science Board (SSB) of the National Academy of Sciences and from specifications generated within NASA. Periodic reassessments of these requirements are undertaken and are motivated by new information concerning the risks and the probability of planetary contamination by terrestrial microorganisms and by advances in the technology of planetary quarantine implementation.

Under this task, evaluations are conducted to support the justification and establishment of these requirements and to estimate their implications upon flight projects.

Work performed during this reporting period related principally to the continuing review by members of the SSB and the Life Sciences Committee (LSC) of PQ constraints imposed upon flight projects.

The SSB had been requested on August 12, 1971 (PQ-293) to review NASA's PQ Policy. Their initial step in this review resulted in an expression of opinions forwarded to NASA on December 13, 1971. NASA responded by adopting a revised policy (PQ-294) consisting of seven (7) major changes. The impact of these policy changes was evaluated and summarized by Exotech in a Summary Report issued on February 9, 1972 (PQ-366). The revised policy recognized the continuing review of probability of growth parameters and hence the revised values of $P(g)$ for Mars and the Outer Planets were adopted on a tentative (for planning purposes only) basis.



Much of the activity undertaken on this task resulted from the tentative nature of these values and the reluctance of the science community to reach a firm consensus.

The SSB at its November 12 - 13, 1971 meeting organized a review group to concentrate on the Viking mission and its related elements of risk, cost, sterilization levels and reliability in lieu of further consideration of the value of $P(g)$ alone. This review led to the recommendation (PQ-405) of an "intermediate approach" to the decontamination of Viking, in which disinfectant cleaning and aseptic assembly would be substituted for terminal heat sterilization to the maximum extent possible.

Exotech analyzed the "intermediate approach," concluding that relatively advanced status of the Viking hardware procurement and assembly process precluded the possibility of taking advantage of this approach. Exotech's results are summarized in a memorandum report to the Planetary Quarantine Officer dated June 13, 1972 (PQ-406).

In this work the sensitivity of the conclusions to the value used for $P(g)$ has been made evident. The 2 decade differential between the tentative value (10^{-6}) and the former, firm value (10^{-4}) could be the primary determinant in the need for terminal heat. An Exotech analysis of the impact of various values of $P(g)$ upon Viking contamination control needs show that terminal heat sterilization of the VLC is definite at $P(g) = 10^{-4}$, but could be displaced by non-heat methods with a $P(g)$ of about 10^{-7} or less.

The Planetary Quarantine Program was subjected to close scrutiny by members of both the SSB and the LSC during the past year, following reduction in the Viking biological payload. Assurances were required that PQ constraints were meaningful, were based upon best available technical grounds and were not capriciously developed. An LSC subcommittee, formed at the Third Meeting (April 15-18, 1972), made an in-depth review of the research basis of the program. Exotech



assisted in organizing the PQO reply, in compiling the pertinent data and members of our staff made three (3) of the presentations to the subcommittee on January 23, 1973.

The PQ policy revision relative to minimum orbital lifetime has been questioned by the Viking '75 Project, and the need for clarification was established. As a result Exotech reviewed this issue and its possible implications on a proposed Viking orbiter dip-in maneuver. It was recommended in our summary memorandum (PQ-408) that orbital lifetime be specified in terms of: twenty (20) years with a reliability equated to the mission allocation, and fifty (50) years, equated to a confidence limit specified as 95%.

The establishment of heat sterilization cycles based upon the inactivation characteristics of only one selected microorganism, viz. Bacillus subtilis var. niger has been of concern to the PQO. Consequently he undertook a series of tests to define the dry heat inactivation characteristics of naturally occurring microorganisms to compare them to those of B. subtilis var. niger. These tests are being conducted at KSC by the U.S. Public Health Service. Exotech is assisting in analyzing the impact of these test results upon the sterilization plans of Viking.

Task 2. Maintain and Operate the Planetary Quarantine Document System

The Quarantine Document System (QDS) is an indexed file of material pertinent to the review of flight project quarantine plans and operations. It supports all three (3) goals of the PQ Program but has been especially valuable in providing ready access to the information needed to assure flight project compliance with PQ requirements.

This task covers the operation, maintenance and updating of the system. It requires the application of techniques for source identification, acquisition criteria, cataloguing and indexing, thesaurus maintenance and growth, and responsive retrieval.



During the contract year, the thesaurus was expanded to ensure rapid retrieval despite the increased size of the collection. All existing documents were re-indexed using the expanded keyword list.

The collection currently numbers 525 documents. It is shelved in eighteen (18) volumes, each consisting of a specially-notated three (3) ring binder with appropriate dividers and tabs.

Task 3. Microbial Contamination Logs

The Committee on Space Research (COSPAR) has asked each launching nation to supply it with information on all planetary missions that will permit the maintenance of a contamination log. For purposes of records and the allocation of contamination probabilities to future missions to planets of biological interest, the Planetary Quarantine Officer requires a log of missions of all nations insofar as data is available.

This task supports the preparation and maintenance of these logs. In particular, it requires:

- Maintaining the existing space logs of United States planetary missions for all planets of biological interest.
- Obtaining data from pre and post launch analyses and entering for new missions as they occur.
- Applying extrapolation and estimation techniques to foreign data when exact data is not available.
- Preparing for the Planetary Quarantine Officer a current log of United States missions for presentation to the Planetary Quarantine Panel of COSPAR at their annual meeting.
- Maintaining in the Planetary Quarantine Office a status board of the United States space log updated within two weeks of the time the data becomes



available, supplying copies by photographic or other means within seventy-two (72) hours following request by the Planetary Quarantine Officer.

A log for the planet Jupiter was prepared and the Mars and Venus logs were updated prior to the COSPAR 1972 meeting in Madrid. Further updates are in process in anticipation of the COSPAR 1973 meeting in May.

Pertinent data from the Microbial Contamination Logs has been extracted and is maintained as a part of the PQ Status Board. These data appear in columns 11, 14 and 15 (see Figure 1). A report on this task was presented by Mr. P. Stabekis on January 30, 1973 at the AIBS Spacecraft Sterilization Seminar in New Orleans, La.

Task 4. Maintenance of Allocation Bank

The United States and the Union of Soviet Socialist Republics plus other launching nations have each been allotted a portion of the total probability of contamination of Mars and with an estimate of the total number of missions that may be flown by each nation. From this data, the Planetary Quarantine Officer makes pre-launch allocations of the probability of contamination that may be used by each nation.

The purpose of this task is to assist the Planetary Quarantine Officer in making the most liberal allocation, consistent with COSPAR policy, to each United States mission. In achieving this goal, the following work was undertaken:

- Data was acquired to maintain, on a current basis, records of the allocation of the probability of contamination to each planetary mission. These data were entered and compiled in columns 17, 18, and 19 of the PQ Status Board (see Figure 2).
- The recapture technique, whereby a completed flight mission is reviewed and suballocations to events which

FIGURE 1
PLANETARY QUARANTINE STATUS BOARD

PLANET	MISSION	PROBABILITY OF CONTAMINATION		
		INITIAL ALLOCATION	PRELAUNCH ESTIMATE	POSTLAUNCH ESTIMATE
MARS	MARINER 7	3×10^{-5}	NIL	NIL
	MARINER 8	7.1×10^{-5}	NIL	NIL
	MARINER 9	7.1×10^{-5}	2.8×10^{-5}	1.6×10^{-5}

FIGURE 2
PLANETARY QUARANTINE STATUS BOARD

PLANET	MISSION	ALLOCATION BANK		
		BALANCE of P_c	CUMULATIVE BALANCE	ADDITIONAL ALLOCATION
M A R S	MARINER 7	3×10^{-5}	15×10^{-5}	14.2×10^{-5}
	MARINER 8	7.1×10^{-5}	7.9×10^{-5}	
	MARINER 9	5.5×10^{-5}	13.4×10^{-5}	5.6×10^{-5}



did not occur are identified and "recaptured," was reviewed and implemented. Pertinent data were acquired and entered into the unexpended allocation record for subsequent reallocation to future missions.

- . A reallocation to the Viking mission was recommended utilizing the recapture of unused allocations as the basis for computation.
- . An allocation was recommended for the possible Saturn leg of the Pioneer G Mission.

A report of this task was presented by Mr. E. Bacon at the AIBS Spacecraft Sterilization Seminar on January 30, 1973 in New Orleans.

Task 5. Creation and Maintenance of List of Approved Parameters

Uniformity of policy and facilitation of document review can be effected through a listing of parameters and requirements employed by flight projects in validating compliance with basic PQ constraints. This task covers the preparation of such a listing with definitions, references to pertinent research, and approved numerical values or ranges.

Two categories of parameters have been identified and are monitored under this task. There are:

1. PQO issued parameters — those specified by the PQO, as D values, P(r), etc., as well as those determined or recommended by others and submitted to the PQO for issuance to flight projects.
2. PQO approved parameters — parameters described and estimated by flight projects and submitted in project plans for PQO approval. Examples include: P(uv) for Project X, P(I) for Project Y, etc.



Category 1 parameters have been compiled, formulated and issued in the Planetary Quarantine Specification Sheets (PQ-439). This document is under revision and will be reissued in a more closely controlled version to ensure that the data is current.

Data of the second category have been compiled from documents of the Mariner, Pioneer and Viking projects. Results will be tabulated and summarized for future submittal.

Task 6. Preparation of Technical Information Memo

The Planetary Quarantine Technical Information Memo (TIM) is a brief, informal newsletter containing summaries of research results of note, meetings, significant travel plans, policy decisions, changes in personnel, initiation of new research tasks, and management deadlines. It is submitted to ninety-five (95) people involved in the PQ Program.

Copies of the eight (8) TIMs issued during the contract year are contained in Appendix A.

Task 7. Evaluation of Flight Project Quarantine Plans

Flight projects are required under NHB 8020.12 to prepare and submit to the Planetary Quarantine Officer, as a minimum, a:

- . Planetary Quarantine Plan
- . Microbiological Assay and Monitoring Plan
- . Sterilization Plan
- . Decontamination Plan



The Planetary Quarantine Officer is responsible for the review and approval of these documents as a part of his role of assuring flight project compliance with Planetary Quarantine requirements.

Exotech has assisted the PQO in the review by:

- assessing the feasibility of the proposed methods for fulfilling planetary quarantine objectives,
- confirming the technical suitability of the analysis,
- evaluating the definition and values of the parameters,
- identifying any unusual problems presented in the plan, and
- making recommendations to the Planetary Quarantine Officer bearing on his approval or disapproval of the plan.

During the contract year the following flight project documents were reviewed relative to the objectives cited above:

- Supplement 1 to the Mariner Mars '71 Postlaunch Analysis of compliance with Planetary Quarantine was reviewed and recommended for approval and submission to the COSPAR via the SSB (see PQ-411, 412b and 490).
- The Pioneer 10 Postlaunch Analysis of Compliance with COSPAR Recommendations, NASA/Ames Document PAL-2-20(244-8) (see PQ-378), dated April 19, 1972 was reviewed and found to be complete with respect to NHB 8020.12 (see PQ-489).
- A preliminary draft of the PQ Plan for Mariner Venus-Mercury '73 (PQ-473). Comments were submitted.
- A preliminary draft of the Pioneer G Prelaunch Analysis. Comments are contained in PQ-470.
- Final draft of the Pioneer G Prelaunch Analysis Report (see PQ-560).



Task 8. Supporting Analysis of Planetary Quarantine Sterilization Parameters

Because of the uncertainty in the numerical value of many of the parameters in Planetary Quarantine technology, estimates of these parameters have been used with the consequence that more stringent requirements than might otherwise be necessary are sometimes specified. The degree of parameter uncertainty, however, is steadily being reduced as more research is performed. Past experience has amply demonstrated the usefulness of analytical techniques in the reduction of parameter uncertainties and in integrating new data so as to lead to less stringent and better justified quarantine requirements. This task is directed toward the analytical justification of less stringent PQ requirements.

One analytical study completed during the reporting period involved the manner in which uncertainties enter into the requirements determination process. The relative use of alternative procedures in achieving the desired minimization of excessive safety margins, on the one hand, and their effect on implementation procedures, on the other, has been studied. Recommendations were made concerning the treatment of safety margins as it applies to the specification of PQ constraints as well as their implementation. This work was reported to COSPAR in Madrid by Mr. S. Schalkowsky.

We reviewed Dr. Henry J. Moore's assessment of projectile impact data contained in "An Estimate of Spacecraft Behavior on Impact with Natural Surfaces" (PQ-478). Results correlated well with our earlier analysis of the Boeing Company impact test data. Where differences were noted (no fracture below 750 ft/sec), they were not significant in influencing release parameter values under currently-used methodology. This work is covered in an Interim Report (TP73-01).

The derivation, parameterization, and utilization of microbial heat inactivation data were assessed as a part of a review of the adequacy of D-values and Z-values. Scaling factors and extrapolation techniques have been provided to facilitate the use of test data in sterilization cycle design.



The work of SRI in the analysis of non-linearities in $P(g)$ was reviewed and its possible implications upon existing parameter values and methods is being studied.

Tasks 9 & 10 Preparation of Technical Presentations and Technical Support at Meetings

These tasks relate to the preparation of technical and graphic materials for publications, briefings and speeches on PQ subjects and the provision of related technical support.

During the reporting period materials for the following papers, meetings and publications were prepared:

- . Meeting of the Physical Sciences/Life Sciences Committee, Kennedy Space Center, April 15, 1972
- . COSPAR P.Q.2 — "Developments in the Analysis of Planetary Quarantine Requirements," May 1972.
- . COSPAR P.Q.3 — "Elements in Implementation of Planetary Quarantine Constraints," May 1972.
- . Meeting of Viking '75 PQ Personnel, NASA Headquarters, June 7, 1972.
- . Meeting of Viking '75 PQ Personnel, NASA Headquarters, August 1, 1972.
- . Meeting of Life Sciences Committee, September 8, 1972.
- . AIBS Spacecraft Sterilization Seminar, Atlanta, Ga., September 18-19, 1972.
- . AIBS PQ Panel Meeting, Atlanta, Ga., September 20-21, 1972.
- . Hall, L.B.: A Decade of Development in Sterilization Technology by the U.S. Space Program," Industrial Sterilization Conference, Amsterdam, The Netherlands, September 1972.
- . AIBS PQ Panel Meeting, Atlanta, Ga., October 5-6, 1972.
- . LaRC meeting on planetary quarantine planning for Viking '75, Langley, Va., November 8-9, 1972.



- . Integrated Life Sciences Meeting, NASA Headquarters, November 14-15, 1972.
- . Meeting on Thermal Inactivation of Naturally-Occurring Microorganisms, Kennedy Space Center, December 6, 1972.
- . Meeting with Dr. Lederberg regarding the probability of growth, December 11, 1972.
- . Life Sciences Committee Subcommittee Meeting, NASA Headquarters, January 23, 1973.
- . AIBS Spacecraft Sterilization Seminar, New Orleans, La., January 30-31, 1973.
- . AIBS PQ Panel Meeting, New Orleans, La.,
- . Planetary Quarantine Program Presentation to Dr. Fletcher, NASA Headquarters, February 1973.
- . Meetings on PQ Plans for Viking Orbiter, JPL, Pasadena, February 13, 14, 15, 1973.
- . PQ Program Presentation to Dr. Pickering, JPL, Pasadena, February 16, 1973.
- . "Foundations of Space Biology and Medicine," Chapter 4. "Planetary Quarantine Principles, Practices and Problems," Final draft sent to Dr. White for transmittal to Russia, March 1973. [This effort involved many months of the contract time]

Task 11. Support of Technology Transfer

In addition to the support described above this task requires serving as a source of PQ technology information upon referral of inquiries by the PQO and assisting in the development of the agenda for PQAP meetings.

During the reporting period there were no requests from outside the PQO and his staff for technology information. Assistance was provided, however, in the development of the agendas for the two already-cited PQ group meetings held during the reporting period.



Task 12. Preparation of Planetary Quarantine Schedule

Under this task Exotech periodically prepared a schedule of PQ program activities including flight project document receipt and approval, PQAP, SSB and LSC meetings, semi-annual seminars, SR&T reviews and major travel by PQO staff. This information was integrated and disseminated as part of the TIM. This practice was well received and on October 2, 1972, Task 12 was deleted and it was requested that PQ schedule information continue to be supplied as a part of the TIM (Task 6).

Task 13. Integrated Resumes of NASA Research

During the past eight years, various contractors and NASA Centers have conducted research on different aspects of the same problem. Reports have been submitted on the particular aspect studied, but there does not, in all cases, exist a report or analysis of the resulting whole body of research.

This task is intended to provide resumes of research combining all relevant data from all sources on a specific subject.

No specific assignments have been made under this task; however, several important research areas have been reviewed and pertinent data compiled and reported verbally. These areas include:

- . Microbial release from solids
- . Adhesion of microorganisms to surfaces
- . Probability of surviving ultraviolet radiation
- . Short time-high temperature sterilization
- . Microbial fall out, from atmospheres.



CONCLUSIONS AND RECOMMENDATIONS

The Planetary Program is dealing with a milestone in planetary exploration, viz., the first U.S. Martian lander. As a result the attention of the scientific community has been focused on planetary quarantine. Both the SSB and LSC have closely scrutinized the methodology and technical basis for the program. With the resolution of the Viking experiment complement and the approval of the sterilization approach, it is expected that scrutiny by these and other "outside" groups will diminish.

This exercise, however, points to the need for a well-coordinated and documented research program. Additional research needs remain and should be recognized in program planning. Such needs include:

- Resolution of the "non-linearity" of $P(g)$
- Establishment of PQ-related parameters and factors for the Outer Planets.
- Development of analytical extrapolation between inactivation characteristics of the test organism and naturally occurring contamination
- Resolution of the role of water activity in heat inactivation
- More complete definition of effectiveness of disinfectant cleansing

Exotech will be continuing to provide primary support to the PQO in these issues under the provisions of contract NASw-2503.



APPENDIX A

TECHNICAL INFORMATION MEMOS



TECHNICAL INFORMATION MEMO

Volume 1, Number 1

May 26, 1972

COSPAR MEETING IN MADRID

Larry Hall is in Madrid to attend a COSPAR meeting which includes a session on Planetary Quarantine. The following papers will be presented at this session:

The Impact of Mariner 9 Data on the Need for Quarantine of Mars, by C. Sagan
Developments in the Analysis of Planetary Quarantine Requirements, by O. Reynolds
Elements in Implementation of Planetary Quarantine Constraints, by Brewer
Safety Margins in the Implementation of Planetary Quarantine, by S. Schalkowsky
The Microbiology of the Dry Valleys of Antarctica, by W. Vishniac

The emphasis in the Planetary Quarantine session will be on newly issued U. S. requirements and on the possible impact of the Mariner 9 observations on the constraints applicable to Martian missions. P. Q. needs for the outer planets may also be reviewed and it is hoped that additional contamination analysis results of past flights will be made available by the USSR representatives who are also scheduled to present a variety of papers.

TEN SPECIFICATION SHEETS NOW AUTHENTICATED

Specifications for key parameters needed in estimating contamination probabilities have been issued by P. Q. O. Since February the following specification sheets have become available:

1. Probability of Release of Buried Organisms Under Non-Nominal Landing Conditions
2. Probability of Release of Mated Organisms Under Non-Nominal Landing Conditions

3. **Probability of Release by Erosion of Mated Microorganisms Under Soft Landing Conditions**
4. **Probability of Release of Surface Organisms Under Non-Nominal Landing Conditions**
5. **Probability of Release by Erosion of Surface Organisms Under Soft Landing Conditions**
6. **Average Encapsulated Microbial Density**
7. **Probability of Surface Organisms Surviving Ultra-Violet Radiation**
8. **Source-Specific Encapsulated Microbial Density**
9. **Probability of Release by Erosion of Encapsulated (Buried) Microorganisms Under Soft Landing Conditions**
10. **Probability of Survival of Surface Organisms Exposed**

Copies of the specification sheets can be received from the Editor, E. L. Greenman.

SCHEDULED EVENTS

Events underway or scheduled for the near future include:

1. **The COSPAR Meeting: 10-24 May, in Madrid, Spain**
2. **The SSB/Viking Meeting: 9 June, NASA Headquarters, D. C.**
3. **The AIBS Seminar: 18-19 July, San Francisco**
4. **The Advisory Panel Meeting: 20-21 July, San Francisco**

For further information on any of the above meetings, contact Mrs. S. Gallagher at NASA Headquarters (tel. 755-3760).



PLANETARY QUARANTINE

TECHNICAL INFORMATION MEMO

Volume 1, Number 2

June 19, 1972

Issued by Exotech Systems, Inc., 525 School Street, S. W.,
Washington, D.C. 20024, by direction of NASA's Planetary
Quarantine Officer.

COSPAR MEETING HELD IN MADRID

L.B. Hall, J. Brewer, R. Porter, O. Reynolds and S. Schalkowsky
attended and have returned from the COSPAR Planetary Quarantine meeting
in Madrid, Spain.

At this meeting, V.T. Vashkov of the U.S.S.R. gave a paper on
May 19 that dealt largely with the absorption and release of methyl bromide-
ethylene oxide gas (their so called "OB mixture") by spacecraft parts, par-
ticularly the plastics. During the discussion following this paper Vashkov
answered questions on the measures used to sterilize Mars 2 and 3. Dr. L.B.
Hall has reported (PQ-403) on this presentation and concludes:

"A gross analysis of the above suggests that the measures
used may well limit the landing by each flight to approxi-
mately 1×10^3 viable organisms on the Martian surface,
depending largely on the care exercised in carrying out
the measures described, particularly the quality of the
clean room operations and the cleaning or decontamina-
tion of mated surfaces."

NEXT PQ SEMINAR SCHEDULED FOR SAN FRANCISCO

The AIBS is making arrangements for the next PQ seminar at the Jack
Tar Hotel, Geary and Van Ness Avenue, San Francisco, July 18-19. All pro-
spective attendees must pre-register with the AIBS, 3900 Wisconsin Avenue, N.W.,
Washington, D.C. If you have not received a meeting announcement and wish to
attend, please contact Mary Francis Thompson at AIBS (202-244-5581).

OTHER NEWS

D. Taylor and A. Hoffman were at NASA/Headquarters on June 8th to brief the PQO on the justification for the JPL RTOP's prior to the annual SR&T review.

The review of the SR&T program was completed by the Director, Planetary Programs, on June 9 and by the Deputy Associate Administrator, Science on June 12. All three RTOP areas were approved and only one task was flagged for further consideration by the DAA.

The Viking project quarterly review was held at Langley on June 14-15. The review included the latest plans for sterilization/decontamination. L.B. Hall and M. Christensen attended.

The postlaunch analysis report (Ames Document PAL-2-20) for Pioneer 10, launched March 3, 1972, was approved by PQO this month, as was Supplement 1 to the Mariner Mars 1971 postlaunch analysis report. Both documents will be submitted to the SSB for forwarding to COSPAR.

PLANETARY QUARANTINE OFFICE MOVES

The NASA PQ staff is now located at the east end of the 5th floor, (FOB #6). The telephone number remains as 755-3760-63.

SCHEDULED EVENTS

1. Viking Project PQWG Meeting, 12 - 14 July - Denver
2. The AIBS Seminar, 18 - 19 July - San Francisco
3. PQAP Meeting, 20 - 21 July - San Francisco

For further information on any of the above meetings, contact Mrs. S. Gallagher at NASA/Headquarters (telephone 755-3760).



PLANETARY QUARANTINE TECHNICAL INFORMATION MEMO

Volume 1, Number 3

July 12, 1972

Issued by Exotech Systems, Inc., 525 School Street, S.W.,
Washington, D.C. 20024, by direction of NASA's Planetary
Quarantine Officer.

MARTIAN ORBITAL LIFETIME REQUIREMENT

The PQO has been requested to clarify the recent change in this constraint. The orbital lifetime requirement relates to the time interval during which unsterilized spacecraft are prohibited from impacting the planet Mars. The requirement was considered by members of the Space Science Board as a part of their recent review of the NASA PQ policy and the recommendation made was that the period should be extended to end December 30, 2018 instead of December 30, 1988, and that Martian orbiters should have a probability of at least 0.95 of not impacting the planet during the extended period.

In the implementation of this requirement, it is important to note that the SSB recommendation is an addition to the original requirement and not a substitution. The new requirement means that unsterilized spacecraft must be shown to have a probability of Martian impact of less than the flight allocation during the period ending December 30, 1988 and, in addition, have a probability of 0.95 or more of not impacting prior to December 30, 2018. The added constraint is intended to provide for the contingency that biological exploration results in a requirement to preserve the biological integrity of the planet beyond the period of unmanned exploration.

ROLE OF WATER ACTIVITY IN MICROORGANISM DEACTIVATION

KSC teflon ribbon dry heat experiments are being modified for precise humidity measurement and control. Results will be correlated with work of other laboratories, such as PHS Cincinnati, in developing a better understanding of the effect of water activity on the heat resistance of microorganisms.

NHB 8020.12 UNDER REVISION

Revision to NASA's Planetary Quarantine Provisions document, issued in April 1969, is under review by JPL's Mr. George Ervin. Included is consideration of a change in flight project analysis requirements to relate the mission constraint to the number of viable terrestrial microorganisms allowed to be delivered to a planet.

RECENT JPL PROMOTIONS

Dr. Richard H. Green - to Assistant Section Manager
Dr. Daniel M. Taylor - to Superintendent of Life Sciences Research
Mr. Alan R. Hoffman - to Superintendent of PQ Analysis

SCHEDULED TRAVEL AND EVENTS

July 11 - 14,	Viking PQ Review - MMC - Denver, Colo. L. Daspit, J. Martin
July 17,	MM '71 Briefing - JPL - Pasadena, Calif. L.B. Hall, S. Gallagher
July 18 - 19,	AIBS Seminar - San Francisco, Calif.
July 20 - 21,	PQAP - San Francisco, Calif.



PLANETARY QUARANTINE

TECHNICAL INFORMATION MEMO

Volume 1, Number 4

August 2, 1972

Issued by Exotech Systems, Inc., 525 School Street, S. W., Washington, D. C. 20024, by direction of NASA's Planetary Quarantine Officer.

STERILIZATION SEMINAR HELD IN SAN FRANCISCO

The latest PQ seminar was held on July 18-19 in San Francisco with almost 20 papers presented by members of JPL, Univ. of Minnesota, USPHS/Cincinnati, Sandia, USPHS/Phoenix, North Dakota State, Bionetics and Exotech.

Ralph Trujillo discussed Sandia's research in the elimination of the objectionable odor of formaldehyde-based sporicides without reducing their effectiveness. Both gel and liquid forms have been produced which have bactericidal effects similar to simple formaldehyde. Dr. R. Olson summarized Boeing's recent work in the application of RF-generated oxygen plasmas in sterilizing inoculated surfaces of steel strips. Side effects on material surfaces are reported to be minimal.

Mr. Charles Hagen reported on the status of JPL's tests on the effect of space vacuum-temperature on microorganisms carried on spacecraft surfaces. Significant die-off has been observed between 40° and 55°C for spores and between 25°C and 40°C for sporeforming bacteria. Vacuum tests are being run for 180 days ending October 10, simulating space flight to Mars to investigate a possible long term die-off tendency. Dr. J. E. Campbell reported upon the effects of moisture in thermal inactivation of microorganisms. His work shows the necessity for and benefits to be derived from monitoring or controlling humidity during sterilization, and may permit downward revisions in sterilization parameters.

Dr. Dan Taylor reported on early results of lethality tests with electron and proton radiation simulating the jovian belts. The effectiveness of hydrogen peroxide as a decontaminant was reported by Dr. R. Green. Concentrations of 3-5% and 6-15% were shown to be effective against vegetative bacteria and spores, respectively.

PQAP MEETING CANCELLED

The meeting of the PQAP scheduled for July 20-21 was cancelled as a result of the Executive Order concerning Committee Management. This regulation, order #11671, appeared in the Federal Register on June 7, 1972 (Vol. 37 No. 110) and defines the use of advisory and consultative panels and committees by the federal government. The PQO is modifying the procedures of PQAP in accordance with this Executive Order and will shortly re-schedule the PQAP meeting.

U. S. S. R. - MARS 2 AND MARS 3

The latest information on the orbits of the U. S. S. R.'s Mars 2 and 3 indicate periapses of approximately 1380 km and 1500 km respectively. Based upon the atmospheric model used to evaluate the orbit of Mariner 9, the U. S. S. R. spacecraft should remain in orbit more than 100 years, and thus in company with Mariner 9, more than meet the most conservative Planetary Quarantine requirements for orbital lifetime.

MEETING HELD CONCERNING IMPACT ON VIKING OF CAMPBELL'S MOISTURE INACTIVATION TESTS

A meeting attended by interested Viking project personnel, Dr. J. E. Campbell, members of Exotech and Bionetics and PQO staff was held at NASA/DC on August 1, 1972 to discuss the possible implications of Campbell's recent spore inactivation work on the Viking project sterilization plans. Test data taken at 113°C and 125°C at a variety of relative humidities indicate that kill rates equivalent to the NHB 8020.12 D and Z values require that the relative humidity at a temperature of 125°C be less than 0.1% or more than 50%, and, at a temperature of 113°C, be less than 0.25% or more than 50%.

Viking project representatives will review their planned terminal sterilization cycle in the light of these data. Dr. Campbell intends to continue this work to provide additional data. The same group will again review the data in 60-90 days.

MEETINGS

Life Science Senior Staff: 7 August at NASA Headquarters. Mr. M. Christensen will attend.

OSS Review: 8 August in room 5026 at NASA Headquarters.

Life Science Committee will meet at NASA/DC 8 September.

TRAVEL-DR. L. B. HALL

7-8 August, to North Dakota State University at Fargo, North Dakota.

10-11 August, to University of Minnesota at Minneapolis, Minnesota.



PLANETARY QUARANTINE TECHNICAL INFORMATION MEMO

Volume 1, Number 5

September 15, 1972

Issued by Exotech Systems, Inc., 525 School Street, S.W.,
Washington, D.C. 20024, by direction of NASA's Planetary
Quarantine Officer.

B-D SPONSORING AMSTERDAM SYMPOSIUM

A symposium devoted to Industrial Sterilization is being sponsored by Becton-Dickinson. Dr. G. Briggs Phillips will be the chairman. To be held September 26-27 in Amsterdam, The Netherlands, it will feature the following items of possible interest and benefit to the PQ program:

- . Use of Heat as Sterilizing Agent, Dr. I.J. Pflug
- . Formaldehyde Gas as a Sterilant, Dr. J.J. Tulis
- . Sterilization with Ethylene Oxide, Robert R. Ernst
- . Control Procedures to Guarantee Sterility,
Dr. Bertil Nystrom

PQ-sponsored work with possible application in industrial sterilization will be presented and discussed by a round table of Drs. J.H. Brewer, L.B. Hall, I.J. Pflug, M.S. Favero and H.W. Sivinski.

LIFE SCIENCES COMMITTEE MEETS ON PQ

The Life Sciences Committee, accompanied by several members of the SSB, met at NASA on September 8, 1972 to consider status and progress in the development of PQ requirements. Parameter specification sheets defining space survival and microbial inactivation characteristics were presented by the PQO. The need to supplement these specifications for future outer space missions was indicated. The validity of the methodology employed in developing parameter values was questioned by Dr. Eagle. Recent work on the effect of water activity on spore inactivation was presented. Proposed Viking Terminal sterilization plans were reviewed for the Committee.

PQAP MEETING RESCHEDULED

In line with Executive Order #11671 defining the role of government advisory groups, the mission and operations of PQAP are being restructured. Further details may be available at the next panel meeting currently scheduled for October 5-6 in Atlanta.

Items to be considered include:

- Low temperature inactivation of microorganisms

- Laser sterilization

- Plasma sterilization

- PQ related activities of the NASA Life Sciences Committee

- SSB Report on Viking Science Instruments

MEETINGS

B-D Industrial Sterilization Symposium, September 26-27, Amsterdam

AI BS Planetary Quarantine Panel, October 5-6, Atlanta



PLANETARY QUARANTINE

TECHNICAL INFORMATION MEMO

Volume 1, Number 6

October 19, 1972

Issued by Exotech Systems, Inc., 525 School Street, S.W.,
Washington, D.C. 20024, by direction of NASA's Planetary
Quarantine Officer.

REPORT ON AIBS PQ MEETING

AIBS PQ Group meets in Atlanta on October 5-6

The meeting was well attended with personnel of NASA (Hdqts., LaRC and Ames), USPHS/CDC, Bionetics, Thompson Ramo Woolridge, Exotech and JPL, in addition to the members of the PQ group. Dr. Stanley White of the Life Sciences Committee, as an invited guest, provided insight into the PQ related concerns of that committee and the science community which it represents. Dr. Wolf Vishniac joined the meeting as a new member.

PQ Group Subscribes to Current D-Values

Recent test data from 3 series of tests of microbial inactivation were presented by Drs. Campbell, Pflug and Favero. Campbell's and Pflug's data using *B. subtilis* indicated that the upper bound moisture content specification of NHB 8020.12 is compatible with stated D Values at 125°C and extrapolated D Values (using a Z of 21°C) down to and below 110°C. However, some differences in results were noted, these probably attributable to different test conditions. Teflon strip tests of clean room dust continue to show high D Values.

Of concern in the PQ's review of these data were: (1) the consistency of conclusions to be drawn from the three series of tests, and (2) the implications upon the adequacy of current specifications for D and Z values. Data gaps were identified and the desirability of additional tests was indicated. Based upon the limited results available, changes in D and Z values did not appear warranted.

P(vt) Value of Unity Retained

Dr. J. Stern presented a summarization of pertinent test data compiled from several researchers and recommended that the value of P(vt) be reduced. The PQ group, however, felt that the experimental data presented could not support a reduction, but did recommend that consideration be given to a new factor accounting

for anticipated microbial population reduction subsequent to vehicle launch. It was indicated that a large portion of the unprotected vegetative microbial surface burden on hardware, not previously exposed to heat, can be expected to die off during time intervals of the extent necessary for travel to a planet such as Mars, but that this reduction was probably quite independent of vacuum and temperature conditions. The PQO will review the establishment of such a proposed transit-time reduction factor for utilization in flight project PQ analyses.

Viking Sterilization Approach Reviewed

Dr. Howell presented the latest plans for terminal heat decontamination of the Viking lander capsule. The approach consists of these elements:

- . Recognition of further reduction of encapsulated burden through component heat compatibility exposure
- . Imposition of constraints upon assembly environment and personnel to keep burdens to reasonable levels
- . Reduction of burden through system FA (an Engineering test)
- . Bioassays to firm up terminal heat decontamination parameters.

Estimates and analyses have been conducted to define a parameter envelop of 40 hours @ 233° F for the terminal heat decontamination cycle. It was stated that in all probability both the time and temperature actually needed at the most thermally isolated point will be considerably less than these worst case projections.

PQ Group Reviews New Research

Sterilization by plasma gases and laser beams and means for rapid enumeration of microbial burden were considered as candidates for future research. Members of the group expressed great interest in learning more about plasma and laser sterilization techniques and encouraged the PQO to assess their applicability to the PQ program.

TRAVEL

L.B. Hall

Kennedy Space Center

October 12-13

MEETINGS

NASA/Life Sciences Program Management Meeting — November 14-15



PLANETARY QUARANTINE

TECHNICAL INFORMATION MEMO

Volume 1, Number 7

November 16, 1972

Issued by Exotech Systems, Inc., 525 School Street, S. W.,
Washington, D.C. 20024, by direction of NASA's Planetary
Quarantine Officer.

VALUE SPECIFIED FOR $P(st)$

A value of 1×10^{-1} has been established by the PQO for the probability that a microorganism in the vegetative state located on the surface of a spacecraft will survive interplanetary space travel. A specification sheet for this parameter was issued on October 31, 1972. The value was derived from a comprehensive review of inactivation and preservation data from microbiological laboratory research. This work showed that a contamination-free environment, such as interplanetary space, would produce over a period of several weeks, on the order of a one log reduction in the initial vegetative microbial burden. This reduction is not necessarily attributable to the stresses of vacuum and temperature and, hence, the parameter describing survival in interplanetary vacuum-temperature, $P(vt)$, remains unchanged.

INTEGRATED LIFE SCIENCES MEETING HELD

PQ program presentations were made at the Integrated Life Sciences meeting at NASA/Hdq. on November 14-15, 1972. Program objectives, status, progress and plans for the coming year were summarized by Dr. Hall. Dr. R. Green assisted by describing JPL's portion of the overall program. PQ problems currently being addressed were identified as:

- Determination of the inactivation characteristics of wild organisms and prediction of their incidence in spacecraft assembly and test operations
- Need to define PQ requirements for outer planets and their satellites

VIKING BIOASSAY FACILITIES MEETING SCHEDULED

A meeting to plan the facilities and program of microbiological surveillance for Viking '75 during Cape operations will be held at KSC on December 7, 1972. The proximity of this date to the Apollo 17 launch is designed to take advantage of the presence at KSC of many of those involved.

TRAVEL

L.B. Hall	West Coast (JPL, NBL, Ames, SRI)	November 27 — December 3
L.B. Hall	Kennedy Space Center	December 4 — 8
J. Brewer	Kennedy Space Center	December 5 — 8
M. Favero	Kennedy Space Center	December 7 — 8

MEETINGS

Viking Bioassay	Kennedy Space Center	December 7
AIBS Seminar and Panel	New Orleans	January 30 — February 2



PLANETARY QUARANTINE

TECHNICAL INFORMATION MEMO

Volume 1, Number 8

February 5, 1973

Issued by Exotech Systems, Inc., 525 School Street, S. W., Washington, D.C. 20024, by direction of NASA's Planetary Quarantine Officer.

VIKING BIOASSAY FACILITIES DISCUSSED

Viking bioassay facility needs were discussed at a meeting December 7, 1972 at KSC. As presently planned, the USPHS bioassay facilities will be used by the Project. Samples will be collected by the Project and assays will be conducted jointly by teams comprised of Project (MMC for VLC and JPL for orbiter) and USPHS personnel.

KSC FALLOUT TEST RESULTS

Early results of the teflon ribbon fallout tests being conducted by the Center for Disease Control were presented at a meeting at KSC on December 6, 1972. Experimental techniques employed were carefully reviewed by attendees to provide confidence in the validity of extrapolation of these data in the evaluation of inactivation characteristics for sterilization cycles. Further tests have now been completed with Bacillus subtilis var. niger to substantiate experimental procedures.

PIONEER G PRE-LAUNCH ANALYSIS

A revised draft copy of the Pioneer G Prelaunch Analysis report (Ames PC-396) was submitted to the PQO on December 14, 1972 and signed on January 12, 1973. This report is patterned after the Pioneer F report and reflects the experience of that flight.

VIKING BIOLOGY TEAM MEETS

A meeting of the Viking Bioscience experimenters was held at Ames Research Center on December 11, 1972 to review project decontamination plans. Dr. J. Stern of Bionetics and L. Daspit, the Project PQ Officer, presented details of the currently planned sterilization program for the science package.

L.B. HALL VISITS MMC

Dr. L.B. Hall, the PQO, visited MMC in Denver in January 1973 to review Viking progress. Data on the Thermal Effects Test Model (TETM) were presented.

LSC SUB-COMMITTEE MEETS

A meeting of the LSC Sub-Committee to review the PQ program, met at NASA Headquarters on January 23, 1973. The all-day meeting was devoted to a review of PQO-sponsored research and experimentation in quarantine related matters. A review of program policy evaluation was summarized by Dr. Orr E. Reynolds and Dr. L.B. Hall presented the objectives of PQ research. Summary papers were presented in Space Survival Research (Dr. R. Green), Bionumeration (Dr. M. Favero and R. Lyle), Release of Organisms (E. Bacon), Heat Inactivation (Dr. R. Angelotti), Assay of Wild Organisms (Dr. M. Favero), Growth of Organisms (Dr. R. Young and Dr. R. Porter). Mr. S. Schalkowsky related research results to PQ requirements and Dr. J. Stern illustrated Viking project compliance operations.

Presentation material is being compiled for publication.

SEMI-ANNUAL SEMINAR HELD

The AIBS/NASA PQ Spacecraft Sterilization Seminar was held on January 30-31, 1973 in New Orleans and was followed by a meeting of the PQ Panel of the AIBS. Many papers treated PQ aspects of outer planet missions and emphasized the need for further efforts in this area. A provocative paper on stochastic elements of the enumeration of the probability of growth was presented by Dr. Mike Harrison of SRI. Mr. Jack Sivinski presented a paper previously given in Bombay, India to an International Atomic Energy symposium for developing nations on Radiation Preservation of Foods. The paper was entitled, "Thermal Enhancement of Radio Sterilization," authored by Marcel Reynolds and Pat Brennan.

Later issues of the TIM will address other papers of these meetings.

DR. BREWER ON ROAD TO RECOVERY

We are happy to learn that Dr. Brewer is rapidly recovering from his Christmas Day motorcycle accident. He is expected to be able to get back in the saddle in the near future.



APPENDIX B

PQ REFERENCES CITED



REFERENCES CITED

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